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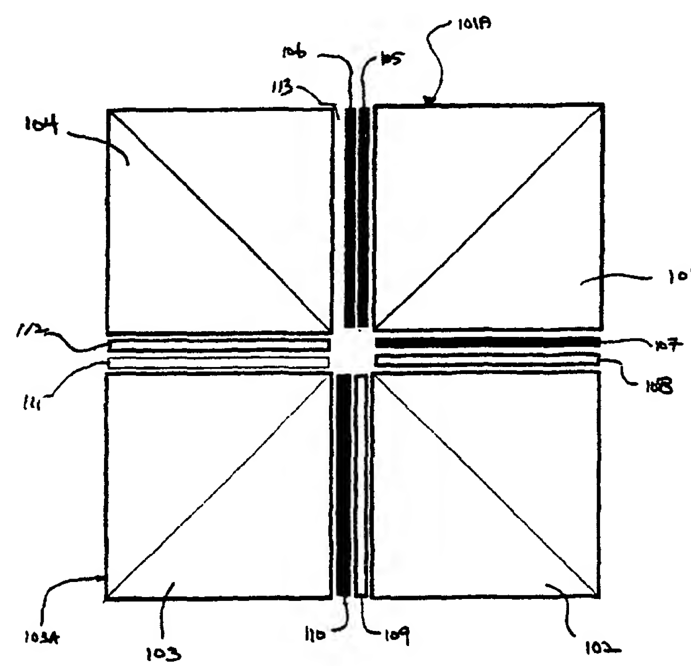
(54) Title: METHOD AND SYSTEM FOR PROVIDING PRISM COMPONENT ASSEMBLY



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(57) Abstract: Method and system for providing high volume manufacturing of the prism assembly for use in microdisplay based light train for video projection applications with dimensional accuracy and without visual defects such as air bubbles is provided minimizing the introduction of defects during the assembly procedure.

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

SPECIFICATION

METHOD AND SYSTEM FOR PROVIDING PRISM COMPONENT ASSEMBLY

RELATED APPLICATION

The present application claims priority under 35 USC §119 to provisional application no. 60/217,758 filed on July 12, 2000.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to microdisplay based light train for video projection applications. More particularly, the present invention relates to method and system for providing a high volume prism assembly procedure for light management system in microdisplay based light train for video projection systems.

2. Description of the Related Art

In the light train assembly of a video projection system, the operation of the light management system begins with a beam of white light channeled on to the input face such as the input surface of the prism assembly in the light management system. The channeled white light is then separated into polarized red, green and blue components which are then directed to a respective one of three microdisplays in the light management system. The component light beams are then modulated by the image information on the respective microdisplays, reflected and then recombined. The modulated white light then exits through the output face such as the output surface of the prism assembly of the light management system to be projected as an image onto a screen.

In commercial applications, the prism assembly may be constructed with numerous components requiring efficient and precise assembly. In particular, to achieve high volume manufacturing, the prism assembly needs to be assembled quickly, with the required dimensional accuracy, and without visual defects such as air bubbles especially in the optical

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path of the light beam, such that the various components of the prism assembly are firmly attached and assembled. That the individual prism components have their unique dimensional tolerances which need to be accommodated during the assembly process adds to the difficulty in the high volume, relatively defect free manufacturing of prism assembly for the light train configurations used in video projection systems.

More specifically, in the star prism assembly, due to its optical design, various mechanical tolerances need to be considered. Indeed, the first tolerance applies to the outside dimensions of the prism assembly which is allowed to fall within a range that has a relatively "loose" tolerance. The next mechanical tolerance relates to the optical path lengths internal to the prism assembly, and in particular, to the distance from the prism assembly faces at the location of the three microdisplays to the output face of the prism assembly. These distances must fall within a "tight" tolerance. Indeed, during the assembly process, the various mechanical tolerances discussed above must be considered and addressed to achieve high volume, star prism assembly manufacturing.

SUMMARY OF THE INVENTION

In view of the foregoing, a method for assembling a prism for use in a microdisplay based light train includes assembling a plurality of stacks, assembling a plurality of beamsplitting cubes, laminating the plurality of stacks to a corresponding one of the plurality of beamsplitting cubes, and assembling a prism configuration after the laminating step.

The step of assembling the plurality of stacks may further include laminating a green dichroic layer to a reflective polarizer layer, laminating a magenta dichroic layer to a blue/yellow waveplate, laminating a red/blue waveplate to a first spacer glass layer, and laminating a half waveplate to a second spacer glass layer.

The step of assembling the plurality of beamsplitting cubes may further include the step of laminating a plurality of first triangular units to a plurality of second triangular units.

Moreover, each of the plurality of beamsplitting cubes may be polarized.

The prism configuration assembling step may include the steps of forming an image

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path subassembly, and laminating an input subassembly to the image path subassembly.

The image path subassembly may include an output surface of the prism assembly and an input surface of the prism assembly.

Additionally, the method may further include the step of applying an anti-reflection coating on the input and output surfaces of the prism assembly, the step of matching optical path lengths of an image path, as well as the step of applying an adhesive to said plurality of stacks, where the applying step may include the step of varying a thickness of the adhesive such that the optical path lengths of an image path are substantially matched. In one aspect, the adhesive may be a layer of glue, while the optical path lengths are matched to be substantially identical.

A method for assembling a prism for use in a microdisplay based light train in accordance with another embodiment of the present invention includes assembling a plurality of stacks, assembling a plurality of polarized beamsplitting cubes, the step of assembling the plurality of beamsplitting cubes including the step of laminating a plurality of first triangular units to a plurality of second triangular units, laminating the plurality of stacks to a corresponding one of the plurality of beamsplitting cubes, and assembling a prism configuration after the laminating step.

A method for assembling a prism for use in a microdisplay based light train in accordance with yet another embodiment of the present invention includes assembling a plurality of stacks, laminating a plurality of first triangular units to a plurality of second triangular units to form a plurality of polarized beamsplitting cubes, laminating the plurality of stacks to a corresponding one of the plurality of beamsplitting cubes, forming an image path subassembly, and laminating an input subassembly to the image path subassembly.

A system for assembling a prism for use in a microdisplay based light train in accordance with still another embodiment of the present invention includes means for assembling a plurality of stacks, means for assembling a plurality of beamsplitting cubes, means for laminating the plurality of stacks to a corresponding one of the plurality of beamsplitting cubes, means for assembling a prism configuration based on the laminating

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means.

The means for assembling the plurality of stacks may include means for laminating a green dichroic layer to a reflective polarizer layer, means for laminating a magenta dichroic layer to a blue/yellow waveplate, means for laminating a red/blue waveplate to a first spacer glass layer, and means for laminating a half waveplate to a second spacer glass layer.

The means for assembling the plurality of beamsplitting cubes may include means for laminating a plurality of first triangular units to a plurality of second triangular units.

Moreover, each of the plurality of beamsplitting cubes may be polarized.

Further, in one aspect, means for assembling the prism configuration assembling may include means for forming an image path subassembly, and means for laminating an input subassembly to the image path subassembly.

The image path subassembly may include an output surface of the prism assembly and an input surface of the prism assembly.

Moreover, the system may further include means for coating an anti-reflection layer on the input and output surfaces of the prism assembly, as well as means for matching optical path lengths of an image path. Additionally, an adhesive layer such as glue may be provided to the plurality of stacks, where the thickness of the adhesive may be varied such that the optical path lengths of an image path are substantially matched.

These and other features and advantages of the various aspects and embodiments of the present invention will be understood upon consideration of the following detailed description of the invention and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure1 illustrates a star prism configuration for a microdisplay based light train in video projection application in accordance with one embodiment of the present invention.

Figure 2 illustrates the components of the star prism configuration of Figure 1 in the sequence of assembly in accordance with one embodiment of the present invention.

Figure 3 illustrates a flowchart for assembling the star prism configuration of Figure 1

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in accordance with one embodiment of the present invention.

Figure 4 illustrates the star prism configuration of Figure 1 including the input and output optical path in accordance with one embodiment of the present invention.

INCORPORATION BY REFERENCE

What follows is a cite list of references each of which is, in addition to those references that may be cited above and below herein, including that which is described as background, and the above invention summary, are hereby incorporated by reference into the detailed description of the preferred embodiment below, as disclosing alternative embodiments of elements or features of the preferred embodiments not otherwise set forth in detail below. A single one or a combination of two or more of these references may be consulted to obtain a variation of the preferred embodiments described in the detailed description below. Further patent, patent application and non-patent references may be cited in the written description and are also incorporated by reference into the detailed description of the preferred embodiment with the same effect as just described with respect to the following references:

United States patent applications no. 60/192,258, 60/192,732, 60/194,735, 60/198,436, 60/200,094, 60/202,265, 60/208,603, 60/210,784, 60/210,285, 60/213,334, 60/214,574, 60/215,932, 60/217,758, 60/220,979, 60/224,617, 60/224,961, 60/224,257, 60/224,503, 60/224,291, 60/224,290, 60/224,060, 60/224,059, 60/224,061, 60/224,289, 60/227,229, 60/229,666, 60/230,330, 60/230,326, 60/232,281, 60/234,415, 60/245,807 and 60/249,815, each of which is assigned to the same assignee as the present application.

DETAILED DESCRIPTION OF THE INVENTION

Figure1 illustrates a star prism configuration for a microdisplay based light train in video projection application in accordance with one embodiment of the present invention. Referring to Figure 1, a star prism configuration 100 for the microdisplay based light train in one embodiment includes four pairs of triangular unit each pair laminated to form polarized beamsplitting cubes 101, 102, 103, and 104. The star prism configuration 100 further includes

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four stacks provided between the polarized beamsplitting cubes 101, 102, 103 and 104. In particular, the stacks in one aspect of the present invention include a green dichroic layer 105 laminated to a reflective polarizer layer 106, a magenta dichroic layer 107 laminated onto a blue/yellow waveplate 108, a red/blue waveplate 110 laminated onto a spacer glass layer 109, and finally, a half waveplate 111 laminated onto another spacer glass layer 112.

Referring back to Figure 1, in one embodiment, each of the stacks comprising the green dichroic layer 105 laminated onto the reflective polarizer layer 106, the stack including the magenta dichroic layer 107 laminated onto the blue/yellow waveplate 108, the stack including the red/blue waveplate 110 laminated onto the spacer glass layer 109, and the stack including the half waveplate 111 laminated onto the spacer glass layer 112 may be laminated onto a corresponding polarized beamsplitting cubes 101, 102, 103 and 104 to respectively form four different types of stack/polarized beamsplitting cube subassemblies. Indeed, with the four different types of stack/polarized beamsplitting cube subassemblies laminated together, the image path subassembly for the light train may be formed.

Referring again to Figure 1, the surface 101A of the polarized beamsplitting cube 101 may be configured as the input surface of the star prism configuration 100, while the surface 103A of the polarized beamsplitting cube 103 may be configured as the output surface of the star prism configuration 100. Moreover, an air gap 113 may be provided between the polarized beamsplitting cube 104 and the stack including the green dichroic layer 105 laminated onto the reflective polarizer layer 106 such that the air gap 113 is maintained between the reflective polarizer layer 113 and the adjacent surface of the polarized beamsplitting cube 104. Furthermore, the input surface 101A and the output surface 103A of the star prism configuration 100 may be provided with an anti-reflection coating. Alternatively, the anti-reflection coating in one aspect may also be provided on the top right and lower left surfaces of the prism configuration.

Figure 2 illustrates the components of the star prism configuration of Figure 1 in the sequence of assembly in accordance with one embodiment of the present invention. Referring to Figure 2, the prism assembly sequence includes initially assembling the stacks 21 by

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laminating the green dichroic layer 105 onto the reflective polarizer layer 106, laminating the magenta dichroic layer 107 onto the blue/yellow waveplate 108, laminating the red/blue waveplate 110 onto the spacer glass layer 109, and finally, laminating the half waveplate 111 onto another spacer glass layer 112. Separately, two triangular units 201, 202 are laminated together to form the polarized beamsplitting cubes 22.

With the polarized beamsplitting cubes, the respective stacks are then laminated onto the polarized beamsplitting cubes thus forming the four different types of stack/polarized beamsplitting cube subassemblies 203, 204, 205, and 206. More specifically, as shown in the Figure, the stack/polarized beamsplitting cube subassembly 203 includes the stack comprising the green dichroic layer 105 and the reflective polarizer layer 106, laminated onto the polarized beamsplitting cube 101. In one embodiment, the stack/polarized beamsplitting cube subassembly 203 may be considered as the input subassembly for the star prism configuration 100.

Referring back to Figure 2, the stack/polarized beamsplitting cube subassembly 204 includes the stack comprising the magenta dichroic layer 107 and the blue/yellow waveplate 108, laminated onto the polarized beamsplitting cube 102, while the stack/polarized beamsplitting cube subassembly 205 includes the stack comprising the half waveplate 111 and the spacer glass layer 112, laminated onto the polarized beamsplitting cube 104. Finally, the stack/polarized beamsplitting cube subassembly 206 includes the stack comprising the spacer glass layer 109 and the red/blue waveplate 110, laminated onto the polarized beamsplitting cube 103.

The three stack/polarized beamsplitting cube subassemblies 204, 205, and 206 are then assembled in the manner as shown in Figure 2 thus forming the optical image path subassembly 24, and thereafter, the input stack/polarized beamsplitting cube subassembly 203 is laminated to the image path subassembly 24 resulting in the star prism configuration 25 for the microdisplay based light train. Indeed, in the manner described above, in accordance with one embodiment of the present invention, the star prism configuration for use in the microdisplay based light train may be fabricated. Furthermore, it should be noted that it is important to

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determine the critical dimensions of each particular combination of components or subassemblies such that the overall dimensions of the star prism configuration may be controlled by adjusting the thickness of glue layers provided therebetween. Moreover, in addition to the embodiments discussed above for assembling the various components of the star prism configuration, within the scope of the present invention, the components may be assembled in a different order so long as the functional integrity of the star prism configuration is maintained.

Figure 3 illustrates a flowchart for assembling the star prism configuration of Figure 1 in accordance with one embodiment of the present invention. Referring to Figure 3, at step 310, the stacks comprising the green dichroic layer 105 laminated onto the reflective polarizer layer 106, the magenta dichroic layer 107 laminated onto the blue/yellow waveplate 108, the red/blue waveplate 110 laminated onto the spacer glass layer 109, and the half waveplate 111 laminated onto the spacer glass layer 112 are assembled. Thereafter at step 320, the pairs of triangular units are laminated to each other resulting in polarized beamsplitting cubes 101, 102, 103, and 104 (Figures 1 and 2).

Referring back to Figure 3, at step 330, the assembled stacks are laminated onto a corresponding one of the polarized beamsplitting cubes 101, 102, 103, and 104, resulting in stack/polarized beamsplitting cube subassemblies 203, 204, 205, and 206 (Figure 2). At step 340, the stack/polarized beamsplitting cube subassemblies 204, 205 and 206 are laminated resulting in the image path subassembly, and at step 350, the stack/polarized beamsplitting cube subassembly 203 which is the input subassembly to the star prism configuration is laminated to the image path subassembly thereby forming the star prism configuration.

Figure 4 illustrates the star prism configuration of Figure 1 including the input and output optical path in accordance with one embodiment of the present invention. It should be first noted that the star prism configuration shown in Figure 4 includes components that are similar to the star prism configuration 100 of Figure 1, and thus, a discussion of the like parts labeled as such will be omitted herein.

Referring to Figure 4, there is provided a green microdisplay 401, a red microdisplay

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402, and a blue microdisplay 403 substantially positioned as shown in Figure 4 in the optical path of the white input light 404 including the corresponding green, red and blue channels 406, 407, 408, respectively. Indeed, as shown in Figure 4, the white input light 404 is provided on the input surface 101A of the polarized beamsplitting cube 101, and configured to exit as the white output light 405 from the star prism configuration 100 at the output surface 103A of the polarized beamsplitting cube 103. Moreover, in one aspect of the present invention, the optical path lengths of the green, red and blue channels 406, 407, 408, respectively are equal such that optical path length matching of the image path is achieved. In a further aspect, an application of glue may be used to achieve variation in joint thickness for the optical path length matching.

Indeed, the star prism assembly configuration of the present invention may include matched optical path lengths, for example, the green, red, and blue channels 406, 407, 408, respectively, such that these optical paths are configured to be substantially identical to each other. Moreover, the subassembly dimensions may also be used to achieve the path length matching, as well as the glue joint thickness variation as discussed above.

In the manner described above, in accordance with the various embodiments of the present invention, there is provided a method and system for high volume manufacturing of the prism assembly for use in microdisplay based light train for video projection applications with the necessary dimensional accuracy and without visual defects such as air bubbles in the prism assembly such that the introduction of defects during the assembly procedure is minimized and the mechanical tolerances of the prism assembly such as the outer dimensions of the prism assembly as well as the optical path lengths internal to the prism assembly are taken into consideration during the assembly process.

Various other modifications and alterations in the structure and method of operation of this invention will be apparent to those skilled in the art without departing from the scope and spirit of the invention. Although the invention has been described in connection with specific preferred embodiments, it should be understood that the invention as claimed should not be unduly limited to such specific embodiments. It is intended that the following claims define the scope of the present invention and that structures and methods within the scope of these claims

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and their equivalents be covered thereby.

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WHAT IS CLAIMED IS:

1. A method for assembling a prism for use in a microdisplay based light train, comprising the steps of:

assembling a plurality of stacks;

assembling a plurality of beamsplitting cubes;

laminating said plurality of stack to a corresponding one of said plurality of beamsplitting cubes; and

assembling a prism configuration after said laminating step.

2. The method of claim 1 wherein said step of assembling said plurality of stacks include the steps of:

laminating a green dichroic layer to a reflective polarizer layer;

laminating a magenta dichroic layer to a blue/yellow waveplate;

laminating a red/blue waveplate to a first spacer glass layer; and

laminating a half waveplate to a second spacer glass layer.

3. The method of claim 1 wherein said step of assembling said plurality of beamsplitting cubes includes the step of laminating a plurality of first triangular units to a plurality of second triangular units.

4. The method of claim 1 wherein each of said plurality of beamsplitting cubes is polarized.

5. The method of claim 1 wherein said prism configuration assembling step includes the steps of:

forming an image path subassembly; and

laminating an input subassembly to said image path subassembly.

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6. The method of claim 5 wherein said image path subassembly includes an output surface of said prism assembly and an input surface of said prism assembly.

7. The method of claim 6 further including the step of applying an anti-reflection coating on said input and output surfaces of said prism assembly.

8. The method of claim 1 further including the step of matching optical path lengths of an image path.

9. The method of claim 1 further including the step of applying an adhesive to said plurality of stacks.

10. The method of claim 9 wherein said applying step includes the step of varying a thickness of said adhesive such that the optical path lengths of an image path are matched.

11. A method for assembling a prism for use in a microdisplay based light train, comprising the steps of:

assembling a plurality of stacks;

assembling a plurality of polarized beamsplitting cubes, said step of assembling said plurality of beamsplitting cubes including the step of laminating a plurality of first triangular units to a plurality of second triangular units;

laminating said plurality of stacks to a corresponding one of said plurality of beamsplitting cubes; and

assembling a prism configuration after said laminating step.

12. The method of claim 11 wherein said step of assembling said plurality of stacks include the steps of:

laminating a green dichroic layer to a reflective polarizer layer;

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laminating a magenta dichroic layer to a blue/yellow waveplate;

laminating a red/blue waveplate to a first spacer glass layer; and

laminating a half waveplate to a second spacer glass layer.

13. The method of claim 1 wherein said prism configuration assembling step includes the steps of:

forming an image path subassembly; and

laminating an input subassembly to said image path subassembly.

14. The method of claim 13 wherein said image path subassembly includes an output surface of said prism assembly and an input surface of said prism assembly.

15. The method of claim 14 further including the step of applying an anti-reflection coating on said input and output surfaces of said prism assembly.

16. The method of claim 11 further including the step of matching optical path lengths of an image path.

17. The method of claim 11 further including the step of applying an adhesive to said plurality of stacks.

18. The method of claim 17 wherein said applying step includes the step of varying a thickness of said adhesive such that the optical path lengths of an image path are matched.

19. A method for assembling a prism for use in a microdisplay based light train, comprising the steps of:

assembling a plurality of stacks;

laminating a plurality of first triangular units to a plurality of second triangular units to

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form a plurality of polarized beamsplitting cubes;

laminating said plurality of stacks to a corresponding one of said plurality of beamsplitting cubes;

forming an image path subassembly; and

laminating an input subassembly to said image path subassembly.

20. The method of claim 19 wherein said step of assembling said plurality of stacks include the steps of:

laminating a green dichroic layer to a reflective polarizer layer;

laminating a magenta dichroic layer to a blue/yellow waveplate;

laminating a red/blue waveplate to a first spacer glass layer; and

laminating a half waveplate to a second spacer glass layer.

21. The method of claim 19 wherein said image path subassembly includes an output surface of said prism assembly and an input surface of said prism assembly.

22. The method of claim 19 further including the step of applying an anti-reflection coating on said input and output surfaces of said prism assembly.

23. The method of claim 19 further including the step of matching optical path lengths of an image path.

24. The method of claim 19 further including the step of applying an adhesive to said plurality of stacks.

25. The method of claim 24 wherein said applying step includes the step of varying a thickness of said adhesive such that the optical path lengths of an image path are matched.

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26. A system for assembling a prism for use in a microdisplay based light train, comprising:

means for assembling a plurality of stacks;

means for assembling a plurality of beamsplitting cubes;

means for laminating said plurality of stacks to a corresponding one of said plurality of beamsplitting cubes; and

means assembling a prism configuration based on said laminating means.

27. The system of claim 26 wherein said means for assembling said plurality of stacks include:

means for laminating a green dichroic layer to a reflective polarizer layer;

means for laminating a magenta dichroic layer to a blue/yellow waveplate;

means for laminating a red/blue waveplate to a first spacer glass layer; and

means for laminating a half waveplate to a second spacer glass layer.

28. The system of claim 26 wherein said means for assembling said plurality of beamsplitting cubes includes means for laminating a plurality of first triangular units to a plurality of second triangular units.

29. The system of claim 26 wherein each of said plurality of beamsplitting cubes is polarized.

30. The method of claim 26 wherein said means for assembling said prism configuration assembling includes:

means for forming an image path subassembly; and

means for laminating an input subassembly to said image path subassembly.

31. The system of claim 30 wherein said image path subassembly includes an output surface of said prism assembly and an input surface of said prism assembly.

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32. The system of claim 31 further including means for coating an anti-reflection layer on said input and output surfaces of said prism assembly.

33. The system of claim 26 further including means for matching optical path lengths of an image path.

34. The system of claim 26 further including an adhesive for application onto said plurality of stacks.

35. The system of claim 34 wherein a thickness of said adhesive may be varied such that the optical path lengths of an image path are substantially matched.

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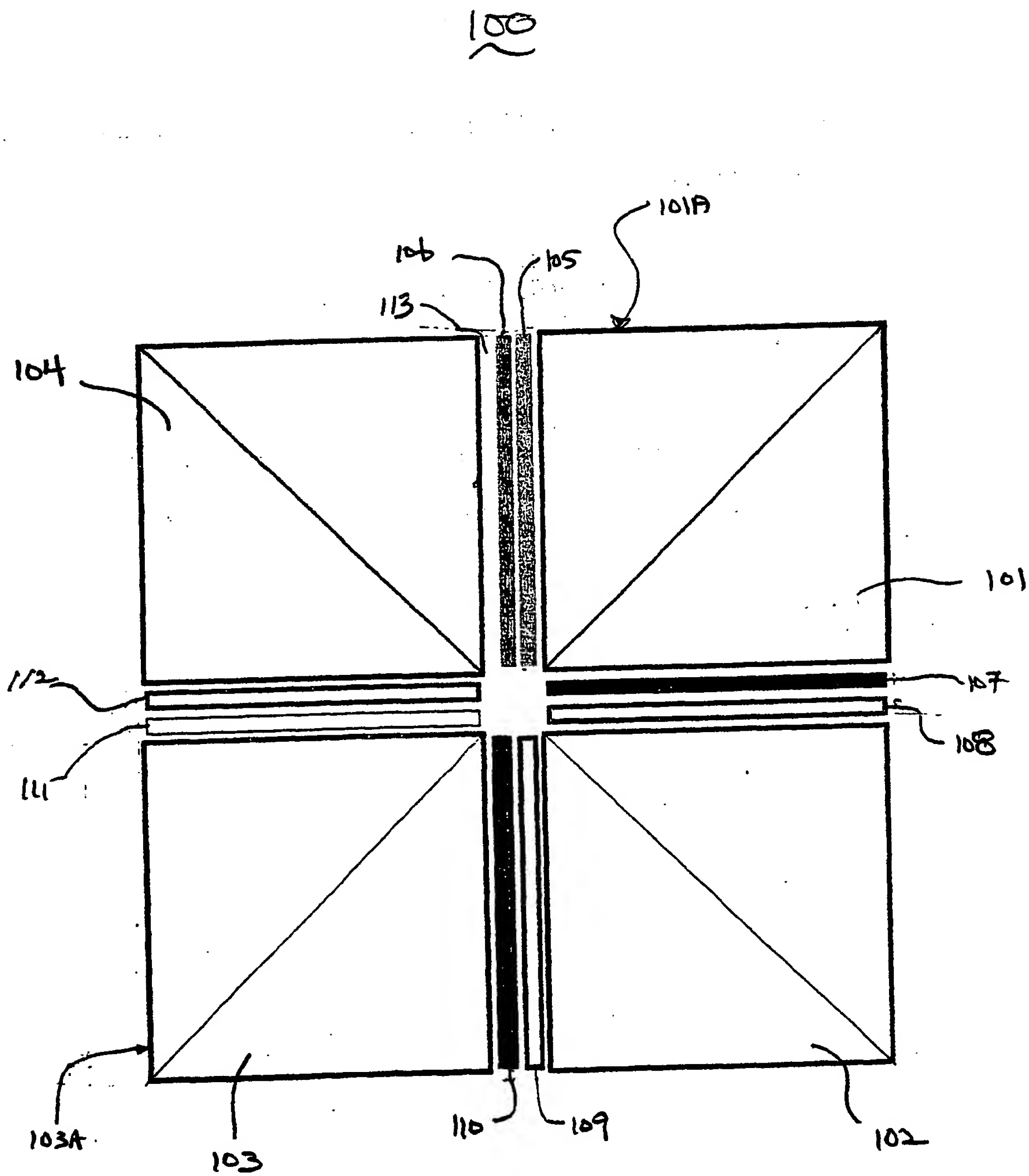
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FIGURE 1

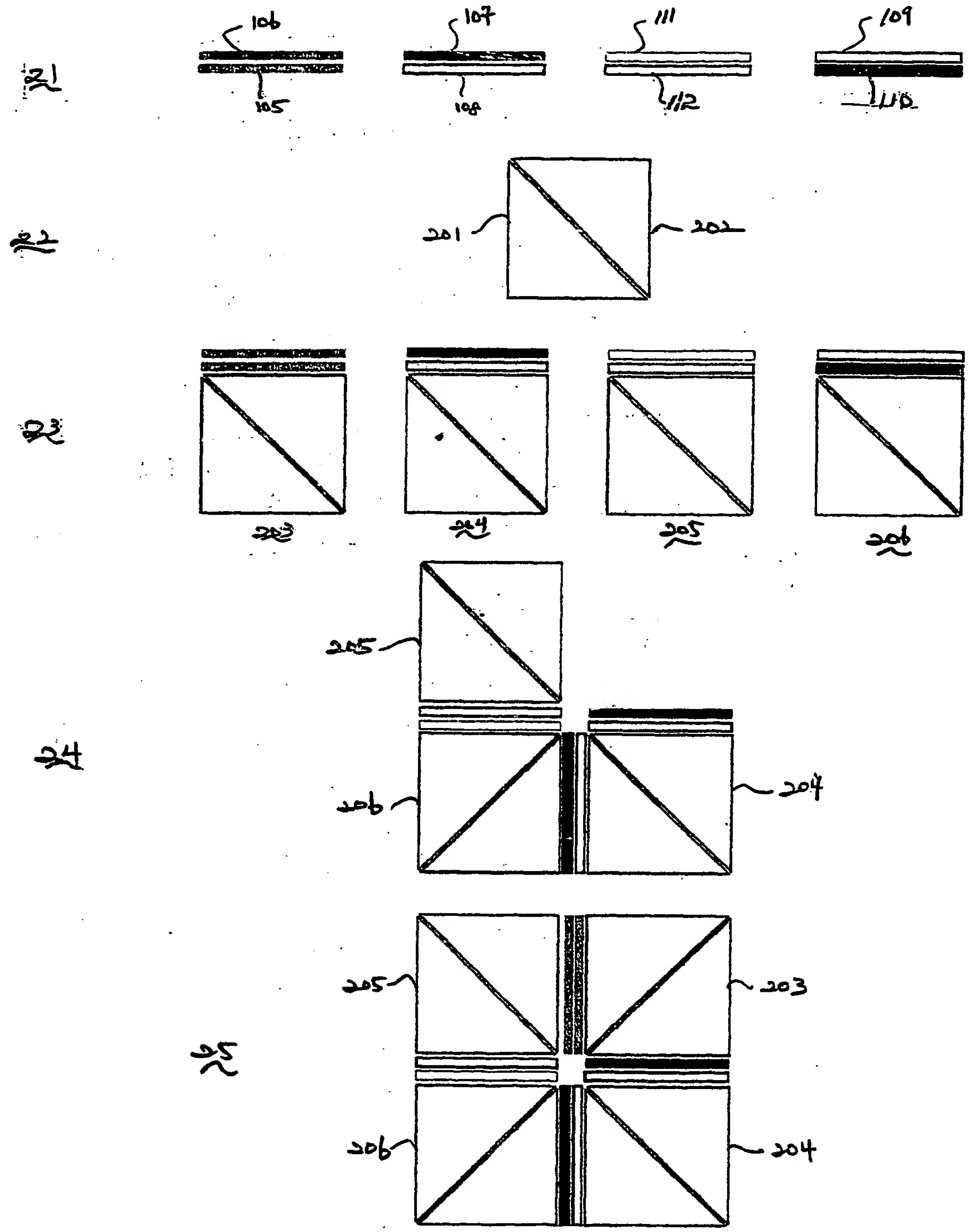
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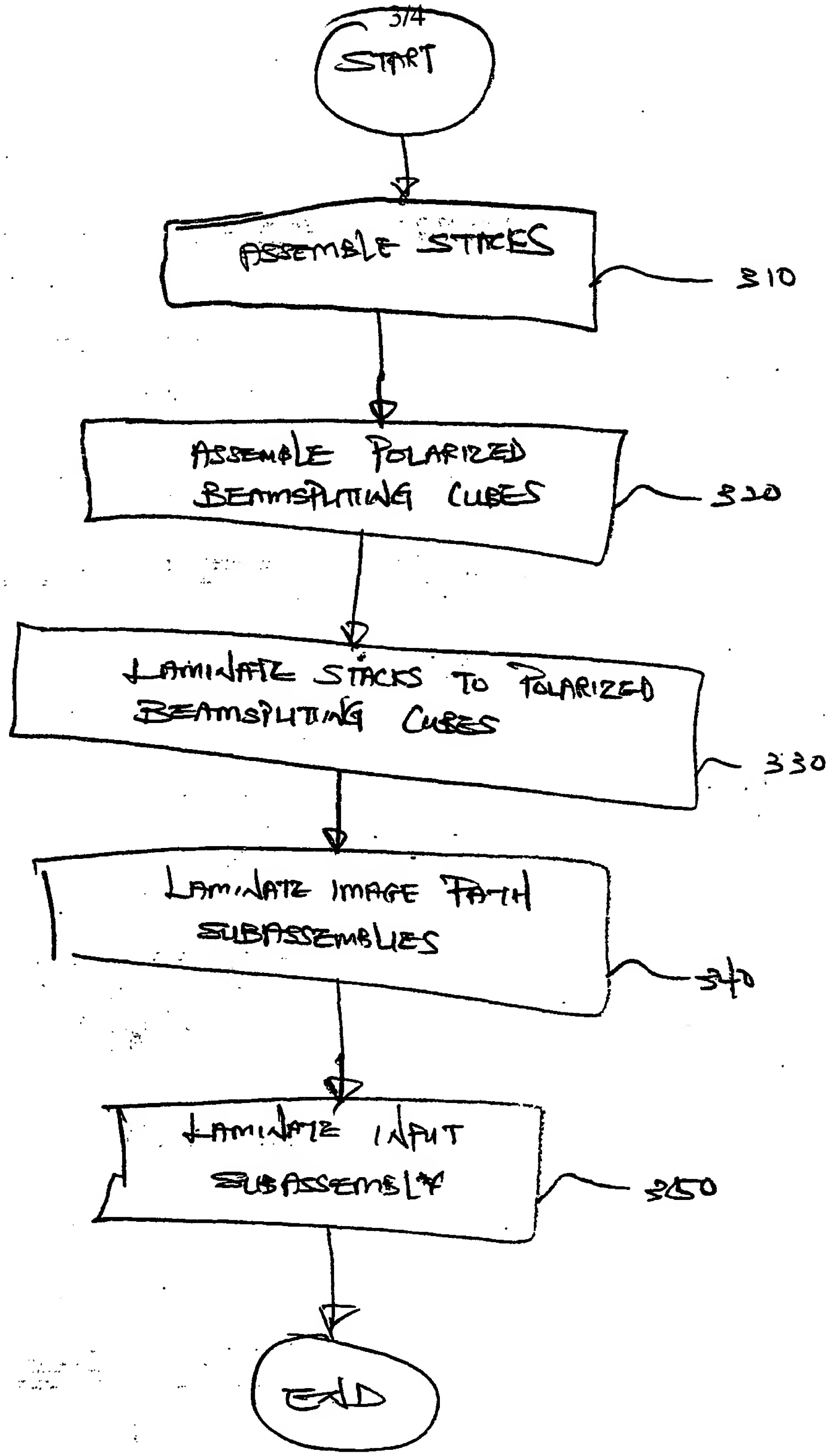
FIGURE 2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ASSEMBLE POLARIZED BEAMSPLITTING CUBES
320
LAMINATE STACKS TO POLARIZED BEAMSPLITTING CUBES
330
LAMINATE IMAGE PATH SUBASSEMBLIES
340
LAMINATE INPUT SUBASSEMBLY
350
END

FIGURE 3

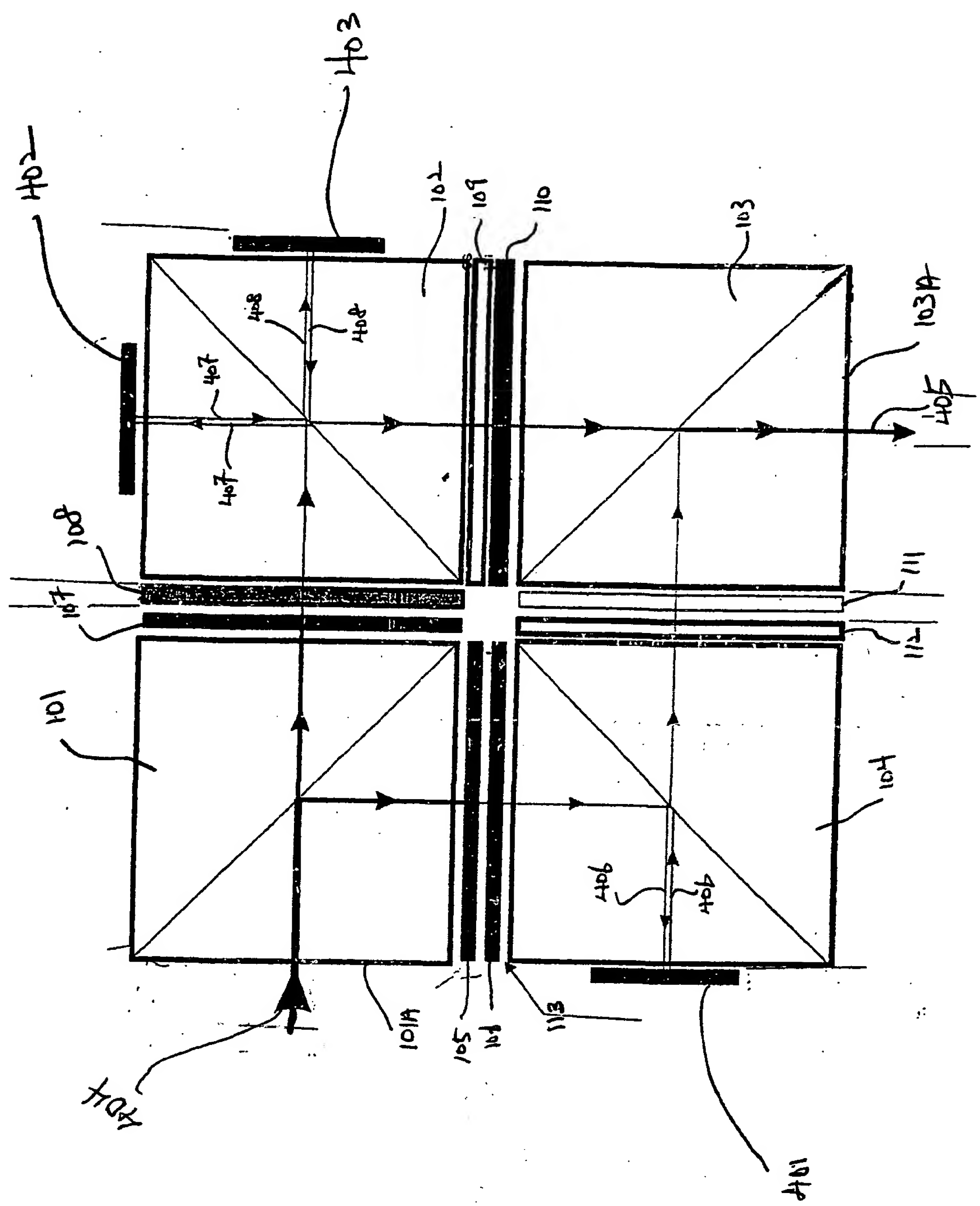
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FIGURE 4.